

001414

An Investigation of Turbulence Incidents

Cooperative  
Research Agreement  
NCC 2-315  
with  
NASA-Ames Research Center

Final Report  
for period ending  
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## A. Introduction.

This is the final report for a cooperative research project which was initiated over 12 years ago in collaboration with Ralph Bach and the late Rodney Wingrove of NASA-Ames. This successful endeavor has resulted in many journal and conference publications describing research into the causes and characteristics of aviation turbulence. This Cooperative agreement also gave students access to a leading research facility and the chance to work with internationally recognized researchers while supporting senior and master's thesis research work. The data set used in the study were unique quantitative measurements of microscale turbulence derived from commercial aircraft. A significant result of the study was the development of a standard turbulence metric based on those available on-board measurements.

## B. Current status of the project.

i) Brian Kahn, currently a Meteorology Graduate Student, William Chan, and Peter Lester will present a poster at the 7th Annual Conference on Aviation Weather Systems on Feb. 4, 1997. This paper is a detailed examination of a severe turbulence incident that occurred on April 12, 1993 near Anchorage, AK using DFDR data obtained from NTSB (copy attached). A majority of this research was conducted by Mr. Kahn for his Senior Thesis.

ii) Through the efforts of William Chan, a copy of SMACK, a state estimation program, is now operational on a UNIX workstation in the Meteorology Department at SJSU. This will help any future work in accident investigation using DFDR data conducted at SJSU.

iii) Meteorologists from Australia have contacted Peter Lester regarding a severe turbulence encounter which occurred earlier this year near Japan. They have asked for assistance in analyzing the aircraft data. It is our intent to continue assisting them by applying SMACK to their data and extracting additional in-flight information necessary to determine the state of atmosphere during this incident.

iv) An archive of turbulence cases has been established in the Meteorology Department at SJSU (see attached table).

## C. Recommendations for future work.

i) Continue work on the validation of the turbulence metric (Wingrove Parameter) by using more high quality research aircraft data.

ii) Examine more turbulence cases using commercial aircraft data to gain a broader understanding of atmospheric turbulence.

iii) Make the archived data available to other researchers. This may require that the data be transformed from their current binary format to a more portable ASCII format.

iv) Compare  $\overline{w'^2}$  vs.  $\overline{u'^2}$  and  $\overline{v'^2}$  to determine the usefulness of these parameters in differentiating between turbulence in stable and unstable layers.

D. Students Supported by this project.

William Chan	Brian Kahn
George Gatsios	Steven King
David Green	Vafa Kordestani
Thanh Hoang	Isadora Mateu
	Jack Molodonoﬀ

E. Bibliography of papers produced during the project.

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Pantley, K. C. and Lester, P. F., 1987: "A High Altitude Turbulence Encounter Downwind of a Thunderstorm." Internal Report, Department of Meteorology, San Jose State University. 21 pp.

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Pantley, K. C., and Lester, P. F., 1986: "A Detailed Analysis of a High Altitude Turbulence Encounter Downwind of a Thunderstorm." *Proceedings of the 24th Aerospace Sciences Meeting*, Reno, NV. 7 pp.

Date	Flight Number	Location	Aircraft	Altitude (feet.)	Disturbance	DFDR
6/75	-	JFK, NY	L-1011	Go-around	Microburst	
11/75	TIA	Calgary, Canada	DC-10	33,000	Clear air turbulence	X
4/81	UA012	Hannibal, MO	DC-10	37,000	Turbulence near thunderstorms	X
7/82	-	Morton, WY	DC-10	37,000	Clear air turbulence	
10/83	AA676	Near Bermuda	DC-10	37,000	Convective turbulence	X
11/83	-	Offshore So. Carolina	L-1011	37,000	Clear air turbulence	
1/85	PAA125 (1)	Over Greenland	B-747	33,000	Mtn. wave turbulence	X
2/85	PAA125 (2)	Over Greenland	B-747	33,000	Mtn. wave turbulence	X
2/85	-	Offshore CA	B-747	41,000	Wind shear	
3/85	AA539	Dallas/Fort Worth, TX	MD-80	Go-around	Microburst	X
8/85	DAL191	Dallas/Fort Worth, TX	L-1011	Landing	Microburst	X
11/85	-	Over Greenland	B-747	33,000	Clear air turbulence	
3/86	-	Offshore HI	B-747	33,000	Clear air turbulence	
4/86	SA534	Jamestown, NY	DC-10	40,000	Wind shear/ maneuvering	X
7/86	-	West Palm Beach, FL	A-300	20,000	Convective turbulence	
9/87	EA924	Near Bermuda	L-1011	31,000	Turbulence near thunderstorms	
11/87	PAA217	Near Bermuda	A-310	33,000	Turbulence near thunderstorms/ maneuvering	X
1/88	AA350	Chicago, IL	B-767	25,000	Clear air turbulence	X
3/88	AA550	Cimarron, NM	B-767	33,000	Mtn. wave turbulence	X
1/90	AA689	Near Puerto Rico	DC-10	-	-	X
5/91	USA1002	Memphis, TN	B-767	-	Undetermined	X
3/93	JA046	Anchorage, Alaska	B-747	3,000	Mtn. wave turbulence	X
4/93	CEA583	Near Shemya, Alaska	MD-11	33,000	Mechanical failure	X

*DFDR data of turbulence incidents investigated at NASA-Ames. Data sets that are still available are marked with an "x".*